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Composition of the zooplankton community of Batata and Mussurá Lakes and of the Trombetas River, State of Pará, Brazil.

by

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Abstract

This research represents an evaluation of the patterns of variation in the composition of the zooplankton community in the region of Porto Trombetas, State of Pará, Brazil. In all, 15 sampling stations were established in the Trombetas River, Mussurá Lake and Batata Lake, at which four series of samples were taken during the extremes of the regional hydrological cycle. At each station, basic limnological variables and zooplankton community composition were determined. Collecting efforts were concentrated in Batata Lake because this lake has received tailings generated from bauxite processing for ten years (1979-1989). Among ambient variables only chlorophyll **a**, water transparency and suspended solids showed changes attributed to the presence of these tailings. The rotifers were highest in number of species, followed by cladocerans and copepods. The three environments differed in zooplankton community composition. These changes were less evident during the filling period when rising water level acted most intensely to interlink the systems, leading to the greatest faunistic homogeneity. Interference from the bauxite tailings could not be clearly identified because for the zooplankton community such interference appears to be a sporadic factor which occurs more intensely during periods such as drawdown.

Keywords: **zooplankton, bauxite tailings, Trombetas River, Neotropics, Brazil.**

Resumo

Esta pesquisa apresenta uma avaliação dos padrões de variação da composição da comunidade zooplanctônica na região de Porto Trombetas (Pará). Ao todo foram estabelecidas 15 estações de amostragens no rio Trombetas, no lago Mussurá e no lago Batata onde foram realizadas 4 coletas durante um ano, em momentos marcantes do ciclo hidrológico da região. Em cada estação foram determinadas variáveis limnológicas básicas e a composição da comunidade zooplanctônica. Os esforços de coletas estiveram concentrados no lago Batata porque este lago recebeu durante 10 anos (1979-1989) o rejeito oriundo do

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processo de beneficiamento de bauxita. Entre as variáveis ambientais apenas clorofila a, transparência da água e sólidos em suspensão apresentaram alterações atribuídas à presença do efluente. Os rotíferos apresentaram o maior número de espécies, seguidos de cladóceros e copépodes. Os três ambientes apresentaram diferenças quanto à composição da comunidade zooplanctônica que parecem menos evidentes na época de cheia, quando a elevação do nível d'água atua interligando de forma mais intensa os sistemas, promovendo maior homogeneização faunística. A interferência do rejeito de bauxita não pôde ser identificada claramente, pois parece ser um fato esporádico para a comunidade zooplanctônica que acontece mais intensamente em épocas como a vazante.

Introduction

In Amazonia there occur innumerable and distinct aquatic ecosystems, which up to the present have been little studied from the ecological point of view. In addition to the spatial diversity of the environments, Amazonia also displays great physionomic changes during the course of a year. These changes are in great part associated with the marked fluctuation in water level that is observed throughout the basin. The alterations in water level occur at different rates of increase and decrease, varying in amplitude, duration, frequency and regularity (JUNK et al.1989). Therefore it is to be supposed that the aquatic communities display compositional patterns related to these factors.

Interest in the temporal pattern of variation of the zooplankton community as a function of changes in water level and their consequences is evident in many works (BRANDORFF 1977; BRANDORFF & ANDRADE 1978; HARDY 1978; CARVALHO 1983; HARDY et al. 1984; HARDY 1989; BOZELLI & ESTEVES 1991). Other authors have treated the zooplankton fauna in a primarily taxonomic manner; among these we can cite KOSTE (1972, 1989); KOSTE & ROBERTSON (1983); BRANDORFF (1973a, 1973b, 1976); SILVA et al. (1989).

Beside these aspects, research on the zooplankton community has most recently been related, as have been a large number of other limnological studies, to the great hydrological projects that have led to many and profound alterations in some Amazonian bodies of water. One example is the studies carried out by ROBERTSON (1980). Moreover considering the changes caused by these major undertakings in Amazonia, it is worthwhile to note those originating from mining activities, which invariably have environmental impacts the nature and magnitude of which are many times unknown. This fact, allied to the lack of knowledge of the structure and function of the impacted ecosystems, imposes new and challenging situations for the understanding of the regional zooplankton community. One evident example of this phenomenon is the bauxite extraction operation at Porto Trombetas (State of Pará), where for ten years the tailings from processing of this mineral were disposed of in Batata Lake, causing environmental changes with characteristics unique in Brazil and possibly in the world (ESTEVES et al. 1990).

Consequently, studies of the zooplankton community of the Amazon region have evolved in the direction of clarifying its role in trophic relationships in the ecosystems, and of evaluating the responses which may occur in cases of anthropogenic alterations. Thus, the present research had as its objective a contribution to knowledge of the distribution of the zooplanktonic organisms, detection of their compositional patterns and identification of possible changes in these patterns caused by the presence of bauxite tailings in Batata Lake.

Study area

The study was carried out in the area between 1°25' and 1°35' S and 56°15' and 56°25' W, near Porto Trombetas in the municipality of Oriximiná, State of Pará, Brazil (Fig. 1).

The Trombetas River lies within the middle Amazon River basin and is a clearwater river, according to the classification of SIOLI (1984).

Mussurá Lake is located on the left bank of the Trombetas River and is continuously connected to the river.

Batata Lake, the central study site, is approximately 2100 ha in area and is situated opposite Mussurá Lake on the right bank of the Trombetas River. Its length is approximately 18 km and its shape extremely dendritic. It is a clearwater lake, like the Trombetas River, and is continuously connected to the river during all seasons of the year.

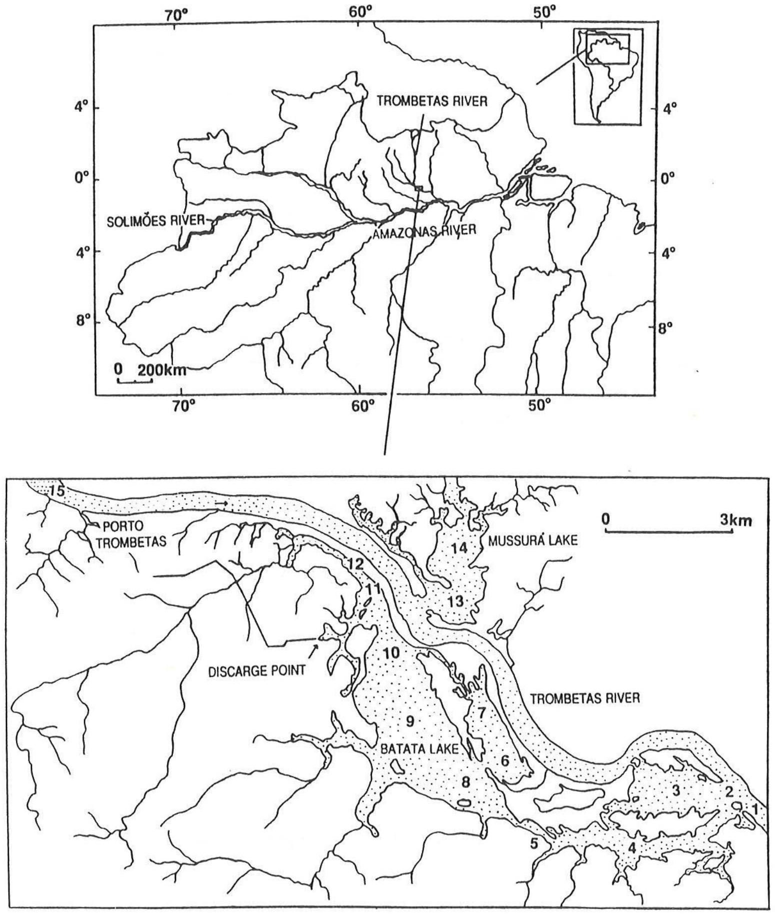

Fig. 1:
Location of the study area and the sampling stations.

The Mineração Rio do Norte S/A mining company initiated its bauxite extraction operations in the Serra do Saracá in 1979. The ore is processed by washing with water jets, which generates a liquid effluent (tailings) containing 7 to 9 % finely granulated solid particles (ca. 96 % smaller than 50 µm), mainly represented by aluminum oxide (21 %), silicates (4 %) and iron oxides, at an annual volume of 18 million m^3 (LAPA & CARDOSO 1988). These tailings were pumped into the upper part of Batata Lake during a ten-year period, until the end of November 1989. According to SILVA (1991), 30 % of the area of the lake came to be affected by the tailings.

Material and methods

The hydrological and pluviometric data used in this work were obtained from the Mineração Rio do Norte meteorological station and include the period January 1984 though December 1989.

Determination of the in situ limnological variables and collection of samples for laboratory analyses were carried out at four periods (3-6 September 1988, 29-30 November and 1 December 1988, 7-10 March 1989 and 20-23 June 1989) over the course of a year and represent four distinct phases of the regional hydrological cycle. These four phases were termed respectively : DRAWDOWN (decreasing water level); DRY (lowest water level); FILLING (rising water level); and FLOOD (highest water level). The 15 sampling stations within the area were distributed as follows (Fig. 1): stations 1 and 15 (Trombetas River); 2-12 (Batata Lake); 13 and 14 (Mussurá Lake). Stations 10, 11 and 12 were located in the area of Batata Lake where the lake sediments were totally covered by tailings and station 9 was located in an area which had indications of tailings. During the dry phase, collections were not carried out at stations 11 and 12, because the lowering of the water level completely exposed these stations.

The temperature of the water column was determined with a FAC400 eletronic thermometer. The water transparency was determined by Secchi disc. Water samples were collected with a Van Dorn bottle at different depths. Samples were collected at the surface and the bottom. Depending on the water level and the thermal profile, additional samples were taken at depths equivalent to three times the Secchi reading depth. When this value reached the lake bottom, the samples were taken at depths which represented half the total water depth. The pH and electrical conductivity of the water were determined with Digimed portable meters. From the samples brought to the laboratory, two 500-ml subsamples were taken and filtered through previously dried and weighed GF/C filters, the filters then redried and weighed to estimate the quantity of suspended solids. Determination of the chlorophyll **a** concentration was performed by filtering known sample volumes through GF/C membranes and by subsequent analysis according to the technique described by GOLTERMAN et al. (1978). Determination of the concentration of dissolved oxygen in the water was made by the Winkler method as modified by GOLTERMAN et al. (1978).

The qualitative zooplankton samples were collected by vertical and horizontal tows using a conical net with 68 µm mesh, 1 m height and 28 cm mouth diameter. The sample concentrated in the cup was transferred to flasks containing a solution of formaldehyde and commercial sucrose as described by HANEY & HALL (1973). In the laboratory the organisms were identified to genus and species using an American Optical microscope. Only the rotifers belonging to the Superorder Monogononta (KOSTE 1978) were identified. Cladocerans belonging to the Families Chydoridae and Macrothricidae were not considered in the analyses, nor were protozoans. Adults, nauplii and copepodids of cyclopoids and calanoids were recorded separately.

In order to compare the species composition at the different stations and times of collection, grouping analysis was carried out using Pearson's binary coefficient to construct a similarity matrix for each collection period. From this matrix an ascending hierarchical classification was developed using the Weighted Pair-Group Method Average (WPGMA) described by SNEATH & SOKAL (1973). This hierarchical arrangement permitted construction of a dendrogram. The results were interpreted considering only those groupings with a similarity of at least 50 %.

Results

Data on variation of the level of the Trombetas River are presented in Fig. 2. From this graph it was possible to demarcate hydrologically distinct periods and to observe the cyclic character of the changes in water level and the exceptional proportions of the 1989 flood phase. During the study period the amplitude of the water level variation of the Trombetas River was 8.36 m. On the same graph are represented data for pluviometric precipitation, which is partly responsible for the variation in water level and has its maximum values during the months of February, March and April, preceding the flood phase; precipitation is generally less in August, September and October.

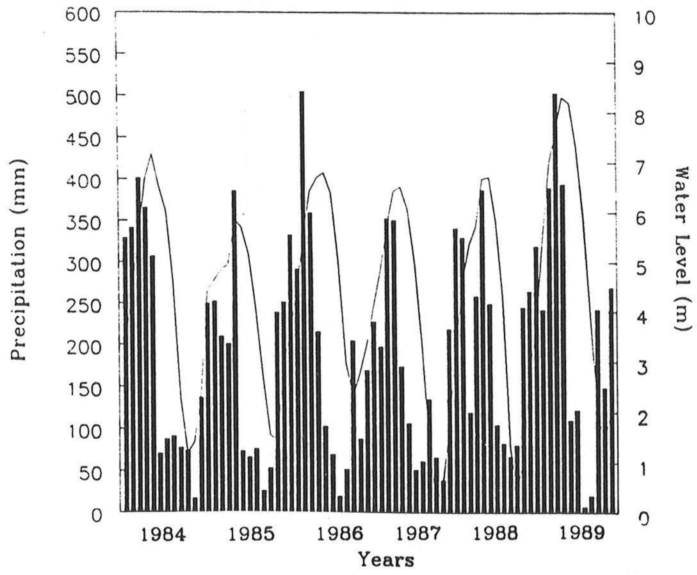

Fig. 2:
Pluviometric precipitation (bars) and the water level of the Trombetas River in excess of 40 m above sea level (line) from January 1984 through December 1989.

Water temperatures at the surface and bottom (Table 1) were higher at the drawdown and dry phases and lower during the filling and flood phases. No thermal effect of the bauxite tailings was detected.

Spatially there were no differences in dissolved oxygen concentrations at the surface, between stations within and outside the area with tailings. Stations 1, 2, 3, 10, 11 and 12 never showed stratification in dissolved oxygen concentration. Temporally there was a general tendency toward destratification during the dry and flood phases, and toward stratification during the drawdown and filling phases. During the latter periods, principally during drawdown, accentuated dissolved oxygen deficits were observed in the lower part of the water column (Table 2) at some stations in Batata Lake (4, 5, 6 and 7) and at the stations in Mussurá Lake.

In Table 3 are presented the pH values at the different collection phases. No differences were found between the areas with and without tailings. Temporally the lowest values were observed during the dry and filling phases. The lowest value observed was 4.5 and the highest was 6.9.

The values for electrical conductivity of the water showed little spatial and temporal variation (Table 4). Stations 13 and 14 (Mussurá) showed, during the dry phase, the highest values of the entire study period, 30 and 23 $\mu S\ cm^{-1}$ respectively. The pattern of variation of conductivity values did not evidence any differences between the areas with and without bauxite tailings. The mean value obtained was 11.2 $\mu S\ cm^{-1}$ (s = 3.8; n = 148).

The concentrations of chlorophyll **a** were greatly reduced at those stations in the area with tailings; this was evident at all seasons, except during the dry phase (Table 5). The temporal variation of the chlorophyll **a** values indicated the highest values at the drawdown and dry phases and the lowest at the filling and flood phases. Concentrations varied between undetectable levels in the area with tailings, and 41.5 $\mu g\ l^{-1}$ at station 7 in the dry phase, when intense phytoplankton development was observed in this part of the lake. The mean value was 4.1 $\mu g\ l^{-1}$ (s = 6.9; n = 149).

Accentuated reduction in water transparency occurred at stations 10, 11 and 12 (tailings-impacted area) at all the different phases except the flood. Stations 6 and 7 showed reduced transparency during the dry phase. It was impossible to identify any temporal pattern of seasonal variation in transparency common to all stations. The maximum visibility value of the Secchi disc was 2.10 m at station 2 at the drawdown phase, and the minimum value was 0.15 m at station 12 at the filling phase (Fig. 3).

Total suspended solids were inversely related to transparency values, but showed less amplitudinal variation. Values were slightly higher at stations with tailings. Stations 6 and 7 showed high values during the dry phase due to intense phytoplankton development.

The values for suspended solids showed a more definite temporal distribution pattern than the values for water transparency. The highest values occurred during the dry phase and diminished with rising water levels (Fig. 3).

The correlation between transparency and suspended solids for the entire study period was significant ($r = -0.6151$; $\alpha = 0.05$).

In regard to the principal groups comprising the zooplankton community, 116 species of rotifers, 12 species of cladocerans and 7 species of copepods were recorded (Table 6).

Among the rotifers, 47 species were recorded during the drawdown phase, 57 species during the dry phase, 52 species during the filling phase and 90 species during the flood phase. Respectively 77.0 %, 86.4 %, 81.2 % and 88.2 % of the total number of species were present during each phase (Fig. 4).

Brachionus gessneri, *Brachionus zahniseri* and *Keratella americana* were the only rotifer species to occur at all stations during the drawdown phase. At this phase, the stations in the area with tailings showed a marked reduction in the number of species present, especially at stations 11 and 12 where only 29.7 % and 12.7 % respectively of the species present in the whole area were recorded.

During the dry phase only *B. gessneri* and *K. americana* were present in the entire area of study. *Lecane proiecta* and *Collotheca* sp. 1 were widely distributed, being absent only at stations 1 and 2 respectively.

During the filling phase, *B. gessneri*, *B. zahniseri* and *K. americana* were recorded at all the stations. *Collotheca* sp. 2, *Polyarthra vulgaris*, *Ptygura libera* and *Trichocerca pusilla* were absent only at a few stations. Station 12 had only 17.3 % of the species present in the entire area.

Tab. 1: Water temperature in °C at surface and bottom in the study area (# indicates samples not collected; * indicates presence of tailings).

		STATIONS														
		1	2	3	4	5	6	7	8	9	10*	11*	12*	13	14	15
DRAWDOWN	surface	29	32	34	33	34	30	30	31	33	33	34	31	30	30	31
	bottom	29	30	30	28	29	29	30	29	29	30	34	31	29	28	31
DRY	surface	33	34	35	35	37	32	31	33	32	33	#	#	31	31	33
	bottom	31	32	32	32	33	32	32	33	32	32	#	#	28	28	32
FILLING	surface	29	31	31	31	31	31	31	31	31	30	29	29	29	28	28
	bottom	28	29	29	27	28	29	29	29	28	29	29	29	27	26	28
FLOOD	surface	27	30	29	27	28	27	29	28	27	27	#	#	30	31	28
	bottom	27	27	27	27	27	26	27	26	26	26	#	#	26	26	27

Tab. 2: Percentages of dissolved oxygen saturation at surface and bottom in the study area (# indicates samples not collected; * indicates presence of tailings).

		STATIONS														
		1	2	3	4	5	6	7	8	9	10*	11*	12*	13	14	15
DRAWDOWN	surface	78	81	84	85	83	66	80	75	93	88	86	86	63	72	84
	bottom	77	76	61	15	17	27	40	42	29	74	#	#	33	69	79
DRY	surface	93	91	95	96	100	84	93	99	96	100	#	#	76	87	89
	bottom	77	90	100	75	91	87	93	99	95	98	#	#	70	83	87
FILLING	surface	206	209	199	95	88	89	89	94	92	84	76	77	88	71	88
	bottom	281	199	156	39	39	88	16	59	10	82	77	77	11	12	84
FLOOD	surface	73	182	88	93	101	96	100	98	105	99	#	#	87	99	71
	bottom	73	95	75	93	95	93	89	89	95	94	#	#	36	23	72

Tab. 3: pH in the study area (# indicates samples not collected; * indicates presence of tailings).

			S	T	A	T	I	O	N	S					
	1	2	3	4	5	6	7	8	9	10*	11*	12*	13	14	15
DRAWDOWN	6,3	6,3	6,2	5,9	6,1	5,9	6,1	6,2	6,1	6,2	6,1	5,2	5,8	6,2	6,4
DRY	6,4	6,1	6,1	5,7	5,5	5,4	5,4	5,8	5,4	5,1	#	#	5,6	5,7	6,4
FILLING	6,2	6,1	6,6	5,9	5,6	5,9	6,4	5,9	5,9	6,2	5,9	5,2	6,5	6,5	6,3
FLOOD	5,8	5,4	5,5	5,5	5,5	5,6	5,5	5,6	5,1	5,3	#	#	5,8	5,8	5,6

Tab. 4: Electrical conductivity of water (µS cm-1) in the study area (# indicates samples not collected; * indicates presence of tailings).

			S	T	A	T	I	O	N	S					
	1	2	3	4	5	6	7	8	9	10*	11*	12*	13	14	15
DRAWDOWN	13	12	11	12	13	12	11	10	11	10	11	9	13	12	12
DRY	13	13	13	9	7	8	8	7	8	8	#	#	30	23	13
FILLING	10	9	10	10	9	8	8	7	9	8	9	9	15	18	10
FLOOD	11	10	10	11	11	10	10	10	13	13	#	#	11	12	10

Tab. 5: Chlorophyll **a** ($\mu g\ l^{-1}$) in the study area (- indicates amounts undetected; # indicates samples not collected; * indicates presence of tailings).

			S	T	A	T	I	O	N	S					
	1	2	3	4	5	6	7	8	9	10*	11*	12*	13	14	15
DRAWDOWN	0,7	3,4	3,6	1,8	5,8	3,9	4,8	2,3	3,3	3,1	-	-	6,7	6,1	0,9
DRY	3,4	4,6	5,5	7,8	7,9	29,4	41,1	15,4	14,8	8,4	#	#	10,3	16,2	2,9
FILLING	0,7	1,4	1,3	2,5	-	1,6	1,8	1,8	1,1	-	-	-	4,6	5,2	-
FLOOD	2,9	1,6	1,5	0,9	0,6	0,7	0,6	1,8	2,2	-	#	#	3,3	1,8	1,5

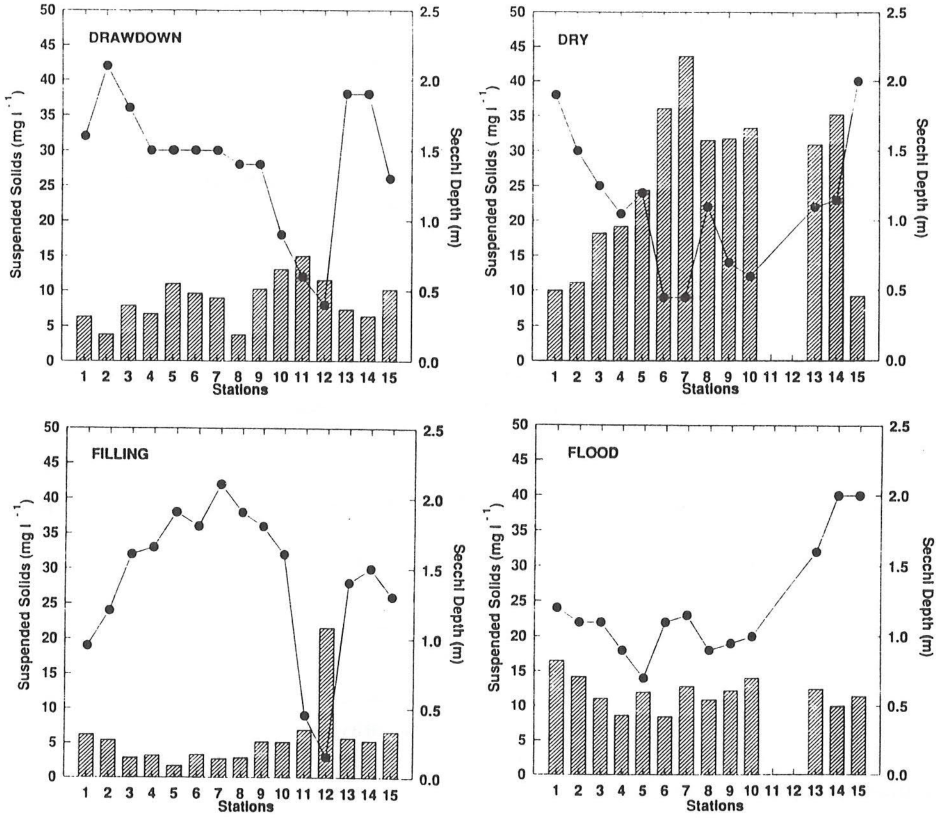

Fig. 3:
Suspended solids (bars) and Secchi disc visibility (lines) at the drawdown, dry, filling and flood phases.

During the flood phase, *B. gessneri*, *B. zahniseri*, *Conochilus dossuarius*, *Filinia longiseta*, *K. americana*, *Keratella cochlearis* and *Synchaeta stylata* were present in the entire study area. *Ascomorpha șaltans*, *Collotheca* spp., *Ploeosoma truncatum*, *Trichocerca similis grandis*, *Trichocerca similis similis*, *Stephanoceros fimbriatus* and *Hexarthra* cf. *mira* were ubiquitous.

The cladoceran community comprised nine species during the drawdown phase, five species during the dry phase and seven species each during the filling and flood phases, respectively 14.8 %, 7.6 %, 11.0 % and 6.9 % of the total number of zooplankton species present at each phase (Fig. 4).

Only *Bosmina hagmanni* and *Ceriodaphnia cornuta* were recorded at all the stations during the drawdown phase. *Bosmina hagmanni* and *Moina minuta* were recorded at all the stations at the dry phase. Besides these species, *Bosminopsis deitersi*, absent from stations 2, 3 and 4 and *Diaphanosoma birgei*, absent from stations 1 and 5, also were widely distributed. *Bosminopsis deitersi* was the only species that occurred at all stations during the filling phase. *Bosmina hagmanni* and *M. minuta* were generally distributed at this phase. *Moina rostrata* and *Diaphanosoma* sp. were recorded only in the Trom-

betas River and Mussurá Lake. *Bosminopsis deitersi*, *C. cornuta*, *Diaphanosoma polyspina* and *M. minuta* were the species recorded at all stations during the flood phase. *Bosmina hagmanni* was absent from station 10 at this phase. *Bosminopsis brandorffi* was recorded at all stations in Batata Lake during the flood phase and was absent at all other phases.

Among the copepods, five species were identified during the drawdown phase, four species during the dry phase and five species each during the filling and flood phases. These constituted respectively 8.2 %, 6.0 %, 7.8 % and 4.9 % of the total number of zooplankton species present during each phase (Fig. 4).

Nauplii and copepods of cyclopoids and calanoids were recorded at all phases and at all sampling stations.

Oithona amazonica occurred at all the phases and at all sampling stations. *Dactylodiaptomus pearsei* occurred only during the flood phase at station 14, Mussurá Lake.

By grouping analysis, seven distinct groups were identified for the drawdown phase (Fig. 5A). The Trombetas River stations (1 and 15) and stations 11 and 12 (large quantities of tailings present) formed four groups. Stations 9 and 10 together formed another group and stations 2, 7, 13 and 14 formed the sixth group. The last group was formed by stations 3, 4, 5, 6 and 8.

For the dry phase, five groups could be identified (Fig. 5B). Stations 1, 13, 14 and 15 formed four distinct groups. The remaining stations formed a single group. Within this group, subgroups could be identified such as that of stations 9 and 10, in the area where tailings were present.

For the filling phase, seven groups could again be arranged (Fig. 5C), indicating the closeness of the pattern to that occuring during the drawdown phase. The stations in the Trombetas River (1 and 15) remained in different groups, as did stations 2, 5 and 8. Stations 3, 4, 13 and 14 composed the sixth group and stations 6, 7, 9, 10, 11 and 12 the final group. The subgroups within these latter two groups were well-defined, each subgroup composed of a pair of stations: 3 and 4, 11 and 12, 6 and 7, 9 and 10 and finally 13 and 14.

For the flood phase, only four groups were identified (Fig. 5D). Again the stations in the Trombetas River constituted two distinct groups. Station 10 remained isolated, however it was very similar to the last group which united all the remaining stations. Subgroups could also be identified for this phase, especially those formed by the stations in Mussurá Lake, next by stations 4 and 6, stations 8 and 9 and finally stations 11 and 12. However it should be noted that the similarity among these subgroups was much greater than observed during the other phases.

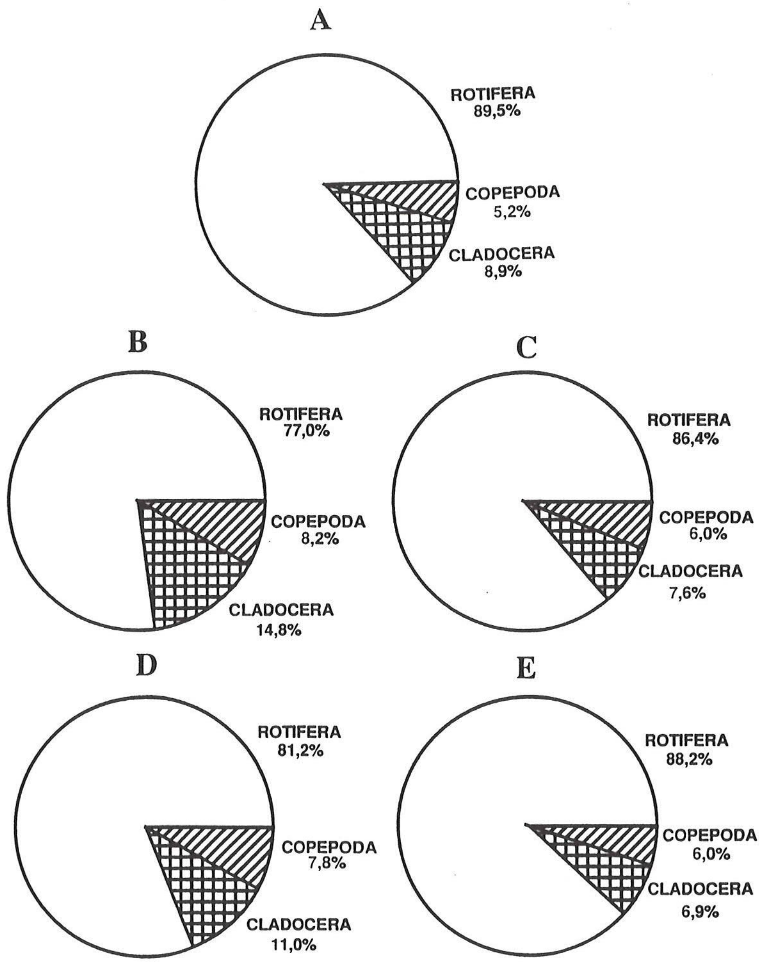

Fig. 4:
Percentage numerical contribution of Rotifera, Cladocera and Copepoda to the zooplankton community during the entire study period (A), the drawdown phase (B), the dry phase (C), the filling phase (D) and the flood phase (E).

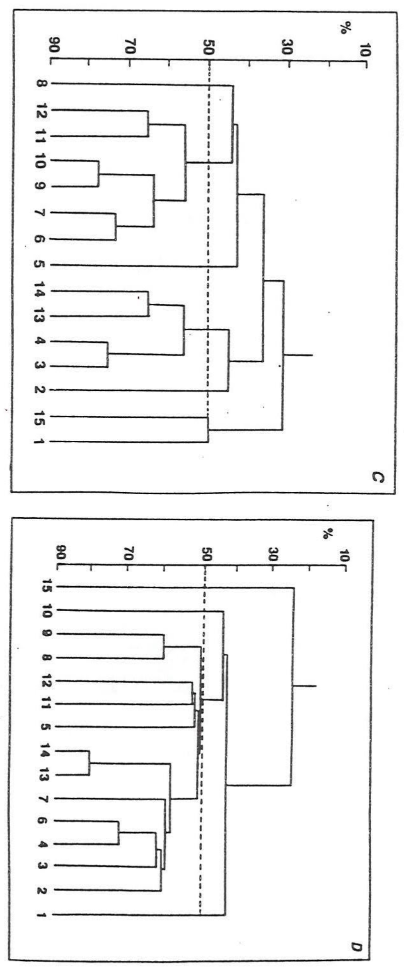

Fig. 5:
Dendrograms developed from species present in the entire study area at drawdown (A), dry (B), filling (C) and flood (D), using Pearson's similarity coefficient.

Tab. 6: Species of zooplankton recorded in the study area from September 1988 through June 1989 (V = drawdown phase; S = dry phase; E = filling phase; C = flood phase).

	Stations 1 VSEC	2 VSEC	3 VSEC	4 VSEC	5 VSEC	6 VSEC	7 VSEC	8 VSEC	9 VSEC	10 VSEC	11 VEC	12 VEC	13 VSEC	14 VSEC	15 VSEC
ROTIFERA															
Anureopsis coelata DE BEAUCHAMP 1932								X							
A. fissa (GOSSE, 1851)	X X	X	XX	XXX	XXX	X X	XXXX	X	XX	X X	XX	X	X XX	X XX	X X
A. navicula ROUSSELET 1910	X	X	X	X	XXX	XXX	XXX	XX	XX	XX	XX		X X	X X	
A. sioli KOSTE 1972		X				X	X					X		X	
Ascomorpha ecaudis (PERTY, 1859)	X	X X	X	X		X X	X		X	X		X	X	X X	X
A. klementi (HAUER, 1965)	XX	XXXX	XX	X X	XX	XXXX	X XX	XX X	X X	X X	X	X	X XX	X XX	XX X
A. saltans BARTSCH 1870	X	X X	X X	X X	X X	X X	X X	X XX	X	X X	XX	X	X X	X	X X
Ascomorpha sp.					X			X	X						
Asplanchna (A.) sieboldi (LEYDIG, 1854)			X		X					X	X	X		X	X
Beauchampiella cf. *eudactylota* (GOSSE, 1886) ?		X								X				X	
Brachionus angularis GOSSE 1851													X	X	
B. dolabratus HARRING 1915													X	X	X
B. falcatus ZACHARIAS 1898														X	X
B. gillardi HAUER 1966				X	X	X	X	X	X				X	X	X
B. gessneri HAUER 1956	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXX	XXX	XXXX	XXXX	XXXX
B. patulus patulus (O.F.M., 1786)									X					X	
B. quadridentatus HERMANN 1783														X	
B. cf. *urceolaris* (O.F.M., 1783)		X													
B. voigti (HAUER, 1961)	X	X	X	X		X	X	X					X X	XX	XX
B. zahniseri AHLSTROM 1934	XXXX	X XX	X XX	X XX	X XX	X XX	X XX	X XX	X XX	X XX	XXX	XXX	X XX	X XX	XXXX
Cephalodella forficula (EHRB., 1838)	X					X					X				
C. cf. *gibba* (EHRB., 1939)									X						
C. cf. *mucronatha* MYERS 1924	X														
Cephalodella sp.	X									X					
Collotheca campanulata (DOBIE, 1849)	X	X							X						XX
Collotheca sp. 1	X	X X	XXXX	XXXX	XXXX	XX X	XX X	XX X	XX X	XXXX	X X	X	XXXX	XXXX	XXXX
Collotheca sp. 2	X XX	X XX	X XX	XXXX	XX	XXX	XXX	XXX	XXX	XX	XX	X	X		XXX
Collotheca sp. 3				X											
Conochilus dossuarius (HUDSON, 1875)	X XX	X XX	X XX	XXXX	XXXX	XXXX	XXXX	XXXX	XX X	XXX	X	X	XXXX	X XX	XXXX
Cupelopagis vorax (LEIDY, 1857) ?							X								
Dipleuchlanis propatula (GOSSE, 1886)	X X								X	X					X
Euchlanis dilatata EHRB. 1832										X X					
E. cf. *incisa* CARLIN 1939										X					
Euchlanis sp			X				X								X
Filinia longiseta (EHRB., 1834)	X X	XX	XXXX	XXXX	XX X	XX X	X X	X	X X	XX X	X X	X	XXXX	XXXX	XXXX

Tab. 6: Continued.

	Stations														
	1 VSEC	2 VSEC	3 VSEC	4 VSEC	5 VSEC	6 VSEC	7 VSEC	8 VSEC	9 VSEC	10 VSEC	11 VEC	12 VEC	13 VSEC	14 VSEC	15 VSEC
F. pejleri HUTCHINSON 1964	x		x		x	x	x	x	x	x			x x	x	x
F. opoliensi (ZACHARIAS, 1891)		x													
Hexarthra cf. *mira* (HUDSON, 1871)	xx x	x	xx x	x x	x	x x	x	x x	x	x x	x	x	xx	xx	x x
Keratella americana (CARLIN, 1943)	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	xxx	xxxx	xxxx	xx x
K. cochlearis (GOSSE, 1951)	x xx	x xx	x x	x xx	x x	x x	x x	x x	x x	x x	x	x	x xx	xxxx	x x
K. lenzi (HAUER, 1953)		x	x						x	x	x	x	x	x	xx
K. nhamunda (KOSTE & ROBERTSON, 1983)		x			x	x	x	x				x			x
Lecane bulla (GOSSE, 1886)	x x			x				x	xx		xx	x	x	x	xx x
L. curvicornis (MURRAY, 1913)	x x				x							x			x
L. cf. *deridderi* KOSTE 1972							x		x						
L. hamata (STOCKES, 1896)										x					
L. leontina (TURNER, 1892)	x	x	xx		xx		x			x		x			
L. ludwigi (ECKSTEIN, 1893)	x	xx						x		x	x	x			xx
L. lunaris (EHRB., 1832)	xx	x xx	x	x	x	x	x	x	x	x		x	x		x xx
L. melini THOMASSON 1953	x	x	x x		x	x	x	x			x				
L. monostyla (DADAY, 1897)				x		x			x					x	
L. murrayi (HAUER, 1965)				x			x				x	x			
L. nodosa HAUER 1937/38			x												
L. cf. *obtusa* (MURRAY, 1913)															x
L. pertica HARRING & MYERS 1926					x							x			
L. proiecta HAUER 1956	x	xxx	xxx	xx	xx	xx	xx	xx	xx	xx			xx	x	xx
L. cf. *pyriformis* (DADAY, 1905)								x			x				
L. quadridentata (EHRB., 1832)											x			x	
L. cf. *remanei* HAUER 1964	x														
L. signifera (JENNINGS, 1896)	xx	xx	x	x		x				x x		x			xx
L. cf. *stichaea* HARRING 1913	xx	x											x	x	
Lecane sp. 1	x														
Lecane sp. 2				x	x										
Lecane sp. 3	x		x					x	x						
Lecane sp. 4						x					x				
Lecane sp. 5														x	
Lecane sp. 6														x	
Lepadella acuminata (EHRB., 1834)														x	
L. cristata (ROUSSELET, 1893)	x				x			xx	x	x					
Lepadella sp. 1					x			x		x	x				
Lepadella sp. 2								x						x	

Tab. 6: Continued.

	Stations														
	1 VSEC	2 VSEC	3 VSEC	4 VSEC	5 VSEC	6 VSEC	7 VSEC	8 VSEC	9 VSEC	10 VSEC	11 VEC	12 VEC	13 VSEC	14 VSEC	15 VSEC
Macrochaetus cf. *collinsi* (GOSSE, 1867)										x					x
M. cf. *serricus* (THORPE, 1893)	x							x			x	x		x	
Macrochaetus sp.					x			x							
Monommata cf. *maculata* H. & M. 1924	x		x								x	xx			x
Mythilina cf. *macrocera* (JENNINGS, 1894)															x
M. cf. *ventralis* (EHRB., 1832)											x x				x
Mythilina sp. 1										x		x	x	x	
Mythilina sp. 2											x	x			
Paranureopsis quadriantennata KOSTE 1974		x	x				x								x
Platyias quadricornis (EHRB., 1832)								x							x
Ploeosoma truncatum (LEVANDER, 1894)	x xx	x x	x xx	xxx	x x	x xx	x xx	xx x	x x	x x	xx	x	xxxx	xx	xx x
Polyarthra vulgaris CARLIN 1943	xxxx	xxx	xxxx	x xx	xxxx	xxxx	xxxx	x x	x xx	xxxx	xxx	xx	xx x	xx x	xx x
Proales sp.								x		x					
Ptygura libera MYERS 1934	x	x x	x x	xxx	xxx	xxxx	xxxx	xxx	xxx	xx	xx	x	x	x x	xxx
Ptygura sp.					x									x	x
Sinantherina ariprepes EDMONDSON 1939				x	x				x						
S. cf. *procera* (THORPE, 1893)										x					
S. cf. *semibullata* (THORPE, 1889)						xx	x						x	x	
S. cf. *socialis* (LINNÉ, 1758)													x		
S. spinosa (THORPE, 1893)															x
Stephanoceros fimbriatus (GOLDFUSS, 1820)	x	x	x xx	xxxx	x xx	xx	xx		x	x	x		xx		xx
Synchaeta stylata WIERZEJSKI 1893	xxxx	x xx	x xx	x xx	x x	x x	x x	x x	x x	x x	x x	x	xxxx	xxxx	xxxx
Testudinella ahlstromi (HAUER, 1956)					x				x	x	x	x			x
T. cf. *incisa* (TERMETZ, 1892)										x					
T. mocronata (GOSSE, 1886)												x			
T. patina (HERMANN, 1783)	x		x					x	x	x	x	x			x
T. ohlei KOSTE 1972	x		x	x	x	x		x		x	x	x			
T. tridentata SMIRNOV 1931	x					x			x						
Trichocerca bicristata (GOSSE, 1887)			x	x	x	x	x	x	x	x	x		x x	x x	x x
T. capucina WIERZEJSKI & ZACHARIAS 1893	x	x x	x	x x	x	x	x	x		x		x	x xx	x xx	x
T. chatoni DE BEAUCHAMP 1907		xx	xx	x	x	x	xx x	x	xx	x			x x	x x	x
T. cf. *collaris* (ROUSSELET, 1896)				x	x	x	x	x							
T. cf. *gracilis* (TESSIN, 1890)						x	x	x					x	x x	x
T. cf. *myersi* (HAUER, 1931)	x	x	x												x
T. pusilla (LAUTERBORN, 1898)		x x	x x	xx	xx	xx	xxxx	xxx	x x	x x	x		x x	xxx	x
T. similis grandis (HAUER, 1965)	xx	x	x	x x	x xx		x x	xx	x xx	x	x x	x	x	xx x	x

Tab. 6: Continued.

	Stations 1 VSEC	2 VSEC	3 VSEC	4 VSEC	5 VSEC	6 VSEC	7 VSEC	8 VSEC	9 VSEC	10 VSEC	11 VEC	12 VEC	13 VSEC	14 VSEC	15 VSEC
T. similis similis (WIERZEJSKI, 1893)	x	xxxx	xxxx	xxx	x xx	x xx	x xx	xxxx	xx x	x	xxx	x	x xx	xxxx	x
T. tigris (O.F.M., 1786)								x							
Trichocerca sp. 1						x							x	xx	
Trichocerca sp. 2													x	x	x
Trichocerca sp. 3													x	x	
Trichocerca sp. 4					x							x			
Trichotria tetractis (EHRB., 1830)	x	x	x	x	x			x	x				x	x	
Trichotria sp.								x							
Trochosphaera aequatorialis SEMPER 1872											x				
CLADOCERA															
Bosmina hagmanni STINGELIN 1904	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	x x	xxx	xxxx	xxxx	xxxx
Bosminopsis brandorffi REY & VASQUEZ 1989	x	x	x		x	x	x	x	x	x		x			x
B. deitersi RICHARD 1895	xxxx	x xx	x xx	x xx	xxx	xxxx	xxxx	xxxx	xxx	xxx	xxx	xxx	xxxx	xxxx	xxxx
Ceriodaphnia cornuta SARS 1886	x xx	x xx	xxxx	xxxx	xxxx	x xx	x x	x xx	x x	x x	x x	x x	xxxx	xxxx	xxxx
Daphnia gessneri (HERBST, 1967)	x	x													x
Diaphanosoma birgei KORINEK 1981	x	x	xx	xxx	x	xxx	x	xx	xxx	xxx	x		x x	x	xx
D. fluviatile HANSEN 1899	xx		x x	xx		xx	xxx	xx	xx	x	x		x x	x x	
D. polyspina KOROVCHINSKY 1982	x xx	x xx	x xx	x xx	x xx	x x	x xx	x xx	x xx	x xx	xxx	x	x xx	x xx	
Diaphanosoma sp.													xx	x	xx
Holopedium amazonicum STINGELIN 1904	x	x x	x	x	x x	x x	x	x x	x x				x	x x	x
Moina minuta HANSEN 1899	xxxx	xxxx	xx x	xxxx	xx x	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	xx	xxxx	xxxx	x
M. rostrata McNAIR 1980	x xx								x	x			x	x	xx x x
COPEPODA															
Aspinus acicularis BRANDORFF 1973	xxx	xx	x	xx	x	xx	x	xx	x x	x			x x	x	x
Dactylodiaptomus pearsei (WRIGHT, 1927)														x	
Microcyclops finitimus DUSSART 1984	xx		x	x	x	xx	x	xx	x	x xx		x			x
Notodiaptomus amazonicus (WRIGHT, 1935)									x	x					
Notodiaptomus sp.	x	xx	x	x				x	x	x			x		
Oithona amazonica BURCKHARDT 1913	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	xxx	xxxx	xxxx	xxxx
Rhacodiaptomus cf. *retroflexus* BRANDORFF 1973		x x				x			x	x x	x	x		x	
Copepodids	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	xxx	xxxx	xxxx	xxxx
Nauplius	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxx	xxx	xxxx	xxxx	xxxx

Discussion

KOSTE (1972), analyzing numerous zooplankton samples from the Amazon region, recorded 206 species of rotifers. In a later study in the region of the lower Nhamundá River, 145 species were recorded (BRANDORFF et al. 1982). In two taxonomic projects carried out in Lake Camaleão on Marchantaria Island in the Solimões River by KOSTE & ROBERTSON (1983) and by KOSTE et al. (1984), 148 and 175 species were recorded respectively.

Two works dealing with the rotifer fauna of clearwaters merit special mention. KOSTE (1974), analyzing samples from Paroni Lake, an oxbow lake of the Tapajós River, State of Pará, recorded 76 species. More recently KOSTE (1989), in a study of Macaco Lake on the left bank of the Trombetas River, upstream from Batata Lake, recorded 48 species.

The number of rotifer species recorded in the present work can be considered high, taking into account that approximately 250 species are known to occur in Amazonia (ROBERTSON & HARDY 1984). This small number of species recorded from a such vast area is, however, due more to the scarcity of research (KOSTE & PAGGI 1982; ROBERTSON & HARDY 1984; KOSTE 1989) than to a real absence of organisms.

The composition of the rotifer fauna in the study area can be considered typically tropical. This is evidenced by the dominance of genera such as *Brachionus* (8.6 %), *Lecane* (21.6 %), *Trichocerca* (12.4 %) and *Testudinella* (5.2 %) and to the absence or minor representation of typically temperate genera such as *Synchaeta* (0.9 %), *Ploeosoma* (0.9 %) and *Notholca* (FERNANDO 1980). The abundance of species of the genus *Lecane* in tropical regions was also mentioned by KOSTE & SHIEL (1983) and DUSSART et al. (1984).

MEDINA & VASQUEZ (1988), studying the rotifer community of Punta Vista Lake, Venezuela, noted the predominance of species of the genera *Brachionus* (30 %), *Trichocerca* (14 %) and *Keratella* (11 %). VASQUEZ & REY (1989) recorded 100 species of rotifers of which the principal genera were *Brachionus* (25 %), *Lecane* (22 %) and *Trichocerca* (15 %). HARDY (1978) observed the dominance of *Keratella cochlearis* and *Brachionus gessneri* during the low water period and of *Brachionus zahniseri* and *Polyarthra* during the period of high waters. This pattern was evident alson in the present study, where *Brachionus gessneri* and *Keratella americana* displayed complete temporal and spatial dominance in the study area. It is worthwhile to note the occurrence of *Collotheca* spp., a genus well-represented in the study area and which must play an important role in the Batata Lake zooplankton community.

SCHADEN (1978) observed that the association of dominant species formed by *B. gessneri*, *B. zahniseri* and *K. americana* can be considered characteristic of black- and clearwaters. This fact can be confirmed for the present study area, composed of clearwater aquatic ecosystems.

The cladocerans recorded in the study area belong to five families. Family Sididae was best represented, with four species in the genus *Diaphanosoma*, of which *D. polyspina* can be considered the dominant, followed by *D. birgei*. *Diaphanosoma* sp. was recorded only at the filling and flood phases in Mussurá Lake. FERNANDO (1980) pointed out the more common occurrence of limnetic species of *Diaphanosoma* in the tropics. Family Bosminidae was represented by three species: *Bosminopsis deitersi*, *Bosminopsis brandorffi* and *Bosmina hagmanni*. *Bosminopsis deitersi* and *B. hagmanni*

occurred generally over the study area while *B. brandorffi* was confined to the flood phase. This species was first found by BRANDORFF et al. (1982) and subsequently by VASQUEZ & REY (1989) in the Orinoco River. The Moinidae was represented by two species - *Moina minuta* and *Moina rostrata*; the former more common, the latter less frequent in occurrence. *Moina rostrata* had previously been recorded only in black- and whitewater systems. In the present study this species occurred preferentially at stations in the Trombetas River or at those stations most closely linked to the river. *Daphnia gessneri* and *Ceriodaphnia cornuta* were the species belonging to the Family Daphnidae recorded in this study. In the Family Holopedidae was recorded the species *Holopedium amazonicum*, a member of a rarely occurring genus in tropical regions (FERNANDO 1980).

The composition of the cladoceran fauna observed in this study is in agreement with that reported by ROBERTSON & HARDY (1984) in their synopsis for the entire Amazon region. These authors pointed out that species such as *B. deitersi*, *C. cornuta*, *M. minuta*, *M. reticulata*, *D. gessneri* and sometimes a species of *Bosmina* or *Diaphanosoma* and occasionally *H. amazonicum* normally dominate numerically. The results of the present study differ from these generalizations only in the absence of *M. reticulata*, in the sparsity of *D. gessneri* and in the higher number of species of *Diaphanosoma*. In Venezuela, research in Lake Valencia and in aquatic systems with hydrological regimes similar to that in the present study area has also recorded the importance of the genus *Bosmina* (TWOMBLY & LEWIS 1987; HAMILTON et al. 1990) and of the species *C. cornuta* (TWOMBLY & LEWIS 1987; HAMILTON et al. 1990; SAUNDERS & LEWIS 1988), *M. minuta* (TWOMBLY & LEWIS 1987; SAUNDERS & LEWIS 1988) and *D. birgei* (SAUNDERS & LEWIS 1988).

Another notable fact is the occurrence of congeneric associations of *Bosminopsis*, *Moina* and *Diaphanosoma*. This aspect has already been noted by BRANDORFF et al. (1982) for *Moina* and *Bosminopsis*. In respect of the genus *Moina* it should be emphasized that differences in density and body size may facilitate coexistence, because they indicate different food habits and population dynamics. For *Diaphanosoma* the situation is more complex, with four species recorded, with apparent temporal separation which requires more intensive sampling to elucidate. The four species did not occur at the same time at a single station and rarely were three species recorded together. The spatial diversity of the study area must have contributed to the occurrence of the several species of *Diaphanosoma*. The *Bosminopsis* association, recorded only during the flood phase, possibly may have been favoured by the hydrological phenomenon which certainly permits enlargement of the habitat, minimizing interspecific competition. HARDY (1978) found a similar situation in the blackwater lakes of Central Amazonia. In these lakes *Bosminopsis deitersi* and *B. negrensis* were apparently associated during the flood period. According to this author, *B. deitersi* occupied the upper layers of the water column, with maximum abundances at the surface, while *B. negrensis* occupied the deeper layers, with greatest abundances at 10 m. *Bosminopsis negrensis* can support the anoxic conditions of the hypolimnion, and is probably a sparse, seasonal species. Possibly *B. brandorffi* and *B. deitersi* in Batata Lake show similar behaviour, however it was impossible to identify this because collections were not made at different depths.

The composition of the copepod fauna showed the usual pattern for Amazonian waters. According to ROBERTSON & HARDY (1984), between one and five species of calanoids and one and three species of cyclopoids normally occur in a single body of

water. In the present work a total of five and two species respectively of these groups of copepods was recorded, although there were never more than four species of calanoids and two species of cyclopoids in any of the three bodies of water studied. For Batata Lake there is also a record of "*Diaptomus*" cf. *negrensis* (B. ROBERTSON, personal communication). BRANDORFF (1978) recorded three species of cyclopoid and five species of calanoids in Lake Castanho, and one species of cyclopoid and seven species of calanoids in Lake Tarumã-Mirím (both in the State of Amazonas). The proposal of BRANDORFF (1976), that *Rhacodiaptomus retroflexus*, *Aspinus acicularis* and "*Diaptomus*" *negrensis* form a species association found only in black- and clearwaters, can be confirmed. *Dactylodiaptomus pearsei* ocurred sparsely, however this species is widely distributed in the Amazon basin (BRANDORFF 1976; SILVA et al. 1989). *Aspinus acicularis* and *Notodiaptomus* sp. were dominant among calanoids as a function both of season and collection station. *Aspinus acicularis* is endemic in Amazonia and is restricted to black- and clearwaters (BRANDORFF 1976, 1978; HARDY 1978). *Dactylodiaptomus pearsei*, *A. acicularis* and *R. retroflexus* have already been recorded by BRANDORFF et al. (1982) in studies of the region of the lower Nhamundá River. Two species of cyclopoid copepods were recorded in the study area. *Microcyclops finitimus* was accidental in occurrence, due to the fact that this species cannot be considered typically planktonic (SILVA et al. 1989). *Oithona amazonica* which was amply distributed with all life stages represented is considered a dominant species in the lakes of central Amazonia (ROBERTSON & HARDY 1984; CARVALHO 1983), throughout the Amazon basin (BRANDORFF et al. 1982; CIPOLLI & CARVALHO 1973) and of the Orinoco River (DUSSART 1984; TWOMBLY & LEWIS 1987; HAMILTON et al. 1990). The genus *Oithona* is basically marine, with two species inhabiting Amazonian fresh waters. While *O. amazonica* is generally distributed throughout the Amazon basin, *O. gessneri* appears to be limited to the Amazon River delta (BRANDORFF et al. 1982).

The group analysis was effective in characterizing the faunistic differences shown by the Trombetas River. These differences reflect the lotic characteristics of the system.

In the dry phase, greater differentiation of the systems could be discerned, when stations located toward the interior of the lakes formed more similar groups. The rise in water level contributed decisively to a greater homogenization of the study area by means of the interlinkage of the systems. Several authors have mentioned the influence of water level fluctuation on the zooplankton community of the Amazon region (BRANDORFF 1977; BRANDORFF & ANDRADE 1978; HARDY 1978; CARVALHO 1973; HARDY et al. 1984; BOZELLI & ESTEVES 1991). PAGGI & PAGGI (1974) considered the variation in water level as a complex variable which signifies not only changes in volume of the basin, but also in current velocity. PAGGI (1981) considered that in addition to the effect of displacement by currents, variations in water level cause losses in zooplankton at the level of species that are less adapted to the rapid alterations in living conditions of the fluvial environments.

The area where bauxite tailings were present was clearly different in zooplankton community composition only during the drawdown phase, although the tailings were permanently present in the area. Although it was not possible to relate these alterations in composition during the drawdown phase exclusively to the presence of the tailings, it is probable that this interference occurs sporadically over short periods, in the form of pulses acting directly on the zooplankton community. The data for water temperature,

electrical conductivity, dissolved oxygen and pH did not show changes between the stations or even collection periods which permitted clear identification of any negative action of the tailings in the water column of Batata Lake. On the other hand, the concentration of chlorophyll **a**, as well as the water transparency were markedly reduced in the area with tailings, while the concentration of suspended matter increased, notably at the drawdown and filling phases. Water transparency and suspended solids showed strong negative correlation, and can be taken as indicators of turbidity (DOKULIL 1979). GEDDES (1984) observed that in Alexandria Lake, Australia, high turbidity makes selective predation by fishes impossible, permiting the persistence of large species, while predation by invertebrates may be sufficient to remove the small species. KIRK & GILBERT (1990) established that the presence of suspended sediments in natural ecosystems may influence the structure of zooplankton communities by favoring rotifers over cladocerans. ROBINSON (1957) found that there was a beneficial effect on survival and reproduction of *Daphnia magna* at low concentrations of suspended substances and that there was a deleterious or toxic reaction at higher concentrations. Copepods probably employ selective raptorial feeding in such nutritionally dilute environments and are less dependent on turbidity variations than daphniids (HART 1987, 1988). HARDY (1989) observed a complete change in community structure and dominance accompanying the annual flood of the Amazon River, in Lake Jacaretinga, State of Amazonas, when *Diaphanosoma sarsi*, *Ceriodaphnia cornuta* and *Daphnia gessneri* were replaced by *Moina reticulata*. This change was associated with the introduction of a large quantity of fine particulate suspended matter which entered the lake with the floodwaters. The author showed in laboratory studies that *M. reticulata* grew and reproduced in the presence of suspended materials whereas *D. gessneri* showed high mortality.

The relationships between suspended solids and the availability of food for zooplankton can also be considered. Suspended solids can indirectly reduce light penetration of the water column, altering primary productivity and directly influencing the quantity and quality of food available to the zooplankton community. The values of suspended solids in Batata Lake tended to be higher in the area where tailings were present. However these values were lower than those observed by HARDY (1989) in Lake Jacaretinga.

Consequently it can be supposed that the tailings from bauxite washing potentially constitute an impacting agent that can act to alter the zooplankton community composition by means of increasing the concentration of tailings in the water column. On the other hand the fact must be considered that the tailings must be suspended, which is a variable situation, dependent on external factors such as strong winds that create water turbulence. Moreover it is considered that the thickness of the water layer determines in great part the action of the tailings on the water.

Detection of the response of the zooplankton community to the presence of tailings in the water column must therefore consider the velocity with which these phenomena succeed one another and the intrinsic dynamics of the populations which can undergo great changes over the course of a few days, whether in the area with tailings present itself, or whether in neighboring areas that are not reached by the tailings and that can act as sources of organisms. On the other hand the presence of these tailings in the area for more than ten years may mean that there has been sufficient time for the zooplankton community to respond adaptively to these new environmental conditions.

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References

BOZELLI, R.L. & F.A. ESTEVES (1991): Influência da flutuação do nível d'água sobre a densidade da comunidade zooplanctônica do lago Mussurá e rio Trombetas - Oriximiná(PA). - In: Anais do VI Seminário Regional de Ecologia, São Carlos, pp.: 47-66.

BRANDORFF, G.-O. (1973a): Neue freilebende Calanoide Copepoden (Crustacea) aus dem Amazonasgebiet. - Amazoniana **4**(2): 205-218.

BRANDORFF, G.-O. (1973b): Die neotropische Gattung *Rhacodiaptomus* Kiefer (Crustacea, Copepoda) mit der Beschreibung von zwei neuen Arten. - Amazoniana **4**(4): 341-365.

BRANDORFF, G.-O. (1976): The geographic distribution of the Diaptomidae in South America (Crust., Cop.). - R. Bras. Biol. **36**(3): 613-627.

BRANDORFF, G.-O. (1977): Untersuchungen zur Populationsdynamik des Crustaceenplanktons im tropischen Lago Castanho (Amazonas, Brasilien). - Kiel, Christian Albrechts Universität, Ph.D.-thesis: 108 pp.

BRANDORFF, G.-O. (1978): Preliminary comparison of the crustacean plankton of a white water and a black water lake in Central Amazonia. - Verh. Internat. Verein. Limnol. **20**: 1198-1201.

BRANDORFF, G.-O. & E.R. ANDRADE, (1978): The relationship between the water level of the Amazon River and the fate of the zooplankton population in lago Jacaretinga, a várzea lake in the Central Amazon. - Studies on Neotropical Fauna and Environment **13**: 63-70.

BRANDORFF, G.-O. KOSTE, W. & N.N. SMIRNOV (1982): The composition and structure of rotiferan and crustacean communities of the lower Rio Nhamundá, Amazonas, Brazil. - Studies on Neotropical Fauna and Environment **17**: 69-121.

CARVALHO, M.L. (1983): Efeitos da flutuação do nível d'água sobre a densidade e composição do zooplâncton em um lago de várzea da Amazônia, Brasil. - Acta Amazonica **13**(5-6): 715-724.

CIPOLLI, M.N. & M.A.J. CARVALHO (1973): Levantamento de Calanoida e Cyclopoida (Cop. - Crust.) das águas da região do Guamá, Capim e Tocantins, com nota sobre a fauna acompanhada. - Papéis Avulsos de Zoologia **27**(8): 95-110.

DOKULIL, M. (1979): Optical properties, colour and turbidity. - In: LÖFFLER, H. Neusiedlersee. The limnology of a shallow lake in Central Europe. Monographiae Biologicae, **37**. - The Hague, Dr. W. Junk Publ.: 151-167.

DUSSART, B.H. (1984): Some Crustacea Copepoda from Venezuela. - Hydrobiol. **113**: 25-67.

DUSSART, B.H., FERNANDO, C.H., MATSUMURA-TUNDISI, T. & R.J. SHIEL (1984): A review of systematics, distribution and ecology of tropical freshwater zooplankton. - Hydrobiol. **113**: 77-91.

ESTEVES, F.A., BOZELLI, R.L. & F. ROLAND (1990): Lago Batata: Um laboratório de limnologia tropical. - Ciência Hoje **64**: 26-31.

FERNANDO, C.H. (1980): The freshwater zooplankton of Sri Lanka, with a discussion of tropical freshwater zooplankton composition. - Int. Revue ges. Hydrobiol. **65**(1): 85-125.

GEDDES, M.C. (1984): Seasonal studies on the zooplankton community of Lake Alexandrina, River Murray, South Australia, and the rate of turbidity in determining zooplankton community structure. - Austr. J. Mar. Freshwat. Res. **35**: 417-426.

GOLTERMAN, H.L., CLYMO, R.S. & M.A.M. OHNSTAD (1978): Methods for Physical and Chemical Analysis of Freshwaters. - 2. ed. Oxford Blackwell (IBP Handbook **8**): 315 pp.

HAMILTON, S., SIPPEL, S.J., LEWIS Jr, W.M. & J.F. SAUNDERS (1990): Zooplankton abundance and evidence for its reduction by macrophyte mats in two Orinoco floodplain lakes. - J. Plankton Res. **12**: 345-363.

HANEY, J.F. & D.J. HALL (1973): Sugar coated *Daphnia*: preservation technique for Cladocera. - Limnol. Oceanogr. **18**: 331-333.

HARDY, E.R. (1978): Composição do zooplâncton em cinco lagos da Amazônia Central. - UFSCar/PPG-ERN, São Carlos, M.Sc.-thesis: 143 pp.

HARDY, E.R. (1989): Effect of temperature, food concentration and turbidity on the life cicle characteristics of planktonic cladocerans in a tropical lake, Central Amazon: field and experimental work. - RHBNC-University of London, Ph.D.-thesis: 337 pp.

HARDY, E.R., ROBERTSON, B. & W. KOSTE (1984): About the relationship between the zooplankton and fluctuating water levels of Lago Camaleão, a Central Amazonian várzea lake. - Amazoniana **9**(1): 43-52.

HART, R.C. (1986): Observations on Calanoid diet, seston, phytoplankton-zooplankton relationships, and inferences on Calanoid food limitation in a silt-laden reservoir. - Arch. Hydrobiol. **111**(1): 67-82.

HART, R.C. (1988): Zooplankton feeding rates in relation to suspended sediment content: potential influences on community structure in a turbid reservoir. - Freshwater Biol. **19**: 123-139.

JUNK, W.J., BAYLEY, P.B. & R.E. SPARKS (1989): The flood pulse concept in river-floodplain systems. Proceedings of the International Large River Symposium. - Can. Spec. Publ. Fish. Aquat. Sci. **106**: 110-127.

KIRK, K.L. & J.J. GILBERT (1990): Suspended clay and the population dynamics of planktonic rotifers and cladocerans. - Ecology **71**(5): 1741-1755.

KOSTE, W. (1972): Rotatorien aus Gewässern Amazoniens. - Amazoniana **3**(3/4): 258-505.

KOSTE, W. (1974): Über Rotatorien aus einem Ufersee des unteren Rio Tapajós dem Lago Paroni. - Gewässer und Abwässer **53/54**: 43-68.

KOSTE, W. (1978): Die Rädertiere Mitteleuropas. - Überordnung Monogononta. Begründet von M. Voigt I. Textband: 673 S.; II. Tafelband: 234 Tafeln, Stuttgart, Harper.

KOSTE, W. (1989): Über Rädertiere (Rotatoria) aus dem Lago do Macaco, einen Ufersee des mittleren Rio Trombetas, Amazonien. - Osnabrücker naturwiss. Mitt. **15**: 199-214.

KOSTE, W. & S.J. DE PAGGI (1982): Rotifera of the Superorder Monogononta recorded from the Neotropics. - Gewässer und Abwässer **68/69**: 71-102.

KOSTE, W. & B. ROBERTSON (1983) Taxonomic studies of the Rotifera (Phylum Aschelmintes) from a Central Amazonian várzea lake, Lago Camaleão (Ilha de Marchantaria, Rio Solimões, Amazonas, Brazil). - Amazoniana **8**(2): 225-254.

KOSTE, W. & R.J. SHIEL (1983): Rotifer communities of billabongs in northern and south-eastern Australia. - Hydrobiol. **104**: 49-56.

KOSTE, W., ROBERTSON, B. & E.R. HARDY (1984): Further taxonomical studies of the Rotifera from Lago Camaleão, a Central Amazonian várzea lake (Ilha de Marchantaria, Rio Solimões, Amazonas, Brazil). - Amazoniana **8**(4): 555-576.

LAPA, R.P. & W. CARDOSO (1988): Tailings disposal at the Trombetas bauxite mine. - Proceedings 117th TMS Annual Meeting, Phoenix. Ed. Larry: 65-76.

MEDINA, M.-L. & E. VASQUEZ (1988): Estudio de los Rotiferos de una laguna de inundación de aguas negras del bajo Caroni, Venezuela. - Mem. Soc. Cien. Nat. la Salle Vol. XLVIII, **130**: 105-119.

PAGGI, J.C. & S.B.J. DE PAGGI (1974): Primeiros estudios sobre el zooplancton de las aguas lóticas del Paraná Medio. - Physis **33**(86): 91-114.

PAGGI, S.B.J. (1981): Variaciones temporales y distribución horizontal del zooplancton en algunos cauces secundarios del rio Paraná medio. - Studies on Neotropical Fauna and Environment **16**: 185-199.

ROBERTSON, B. & E.R. HARDY (1984): Zooplankton of Amazonian lakes and rivers. - In: SIOLI, H. (ed.): The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. Monographiae Biologicae **56**. The Hague, Dr. W. Junk Publ.: 337-352.

SAUNDERS, J.F. & W.M. LEWIS Jr. (1988): Composition and seasonality of the zooplankton community of Lake Valencia, Venezuela. - J. Plank. Res. **10**(5): 957-985.

SCHADEN, R. (1978): Zur Diversität und Identität amazonischer Rotatorienzoome. - Amazoniana **6**: 347-371.

SILVA, E.N.S., ROBERTSON, B., REID, J. & E.R. HARDY (1989): Atlas de copépodos planctônicos, Calanoida e Cyclopoida (Crustacea), da Amazônia Brasileira. I. Represa de Curuá-Una, Pará. - Rev. Bras. Zool. **6**: 725-758.

SILVA, F.R.F. (1991): Influência do pulso de inundação e do efluente de lavagem de bauxita sobre a dinâmica de fósforo, nitrogênio e carbono em um lago amazônico (L. Batata - PA.). - UFSCar/PPG-ERN, São Carlos, M.Sc.-thesis: 128 p.

SIOLI, H. (1984): The Amazon and its main affluents: Hydrography, morphology of the river courses, and river types. - In: SIOLI, H. (ed.): The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. Monographiae Biologicae **56**. The Hague, Dr. W. Junk: 127-175.

SNEATH, P.H.A & R.R. SOKAL (1973): Numerical Taxonomy. - San Francisco, Freeman, 1973, 573 pp.

TWOMBLY, S. & W.M. LEWIS Jr. (1987): Zooplankton abundance and species composition in Laguna la Orsinera, a Venezuelan floodplain lake. - Arch. Hydrobiol./Suppl. **79**(1): 87-107.

VASQUEZ, E. & J.A. REY (1989): A longitudinal study of zooplankton along the lower Orinoco River and its delta (Venezuela). - Annls. Limnol. **25**(2): 107-120.